DOCUMENT RESUME

ED 142 296 PS 009 404

AUTHOR Barclay, Craig R.
TITLE The Executive Control of Mnemonic Activity.
INSTITUTION Illinois Univ., Urbana. Inst. for Child Behavior and Development.
SPONS AGENCY National Inst. of Child Health and Human Development (NIH), Bethesda, Md.
PUB DATE Mar 77
GRANT HD-05951; HD-06864
NOTE 44p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (New Orleans, Louisiana, March 17-20, 1977)

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage.
DESCRIPTORS Adults; *Age Differences; *Cognitive Development; Elementary School Students; Factor Analysis; High School Students; *Memory; *Recall (Psychological); Research Methodology; *Training; Transfer of Training

ABSTRACT

The present experiment focused on the development of a "cumulative rehearsal, fast-finish" rehearsal routine. This study was designed for two purposes: (1) to extend the notion of the "executive function" to the case where continued use of mnemonic routine is a reasonable response to an objective change in an information processing task, and (2) to determine the effects of training on the maintenance and generalization of a rehearsal strategy. The subjects were 62 volunteers chosen from grades 6, 10, and 12 and nine adults. The task was a 6-item (pictures) circular recall task presented in a pause-time paradigm. An automated WGTA apparatus was used. The overall design was mixed and represented by the factorial combination of Grade (6, 10, 12, adults) X Phase (Assessment, Training, Maintenance, Generalization) X Group (training, no training) X Item Type (TBR, TBF) X Serial Position (6). The results showed that adults spontaneously produced a "cumulative rehearsal, fast-finish" strategy in response to both the assessment and generalization tasks while only two 10- and three 12- graders did so. All trained subjects maintained the instructed routine and showed evidence of transfer during generalization. Analyses including adults suggested that the form of trained subjects' generalized strategy became more similar to that of the adults as grade increased. Observational and interview data supported these findings. (Author/MS)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED142296

U S DEPARTMENT OF HEALTH
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

THE EXECUTIVE CONTROL OF MNEMONIC ACTIVITY

Craig R. Barclay

PS009404

This research was supported by Grants HD 06864 and HD 05951 from the National Institute of Child Health and Human Development. A portion of these data were presented at the Society for Research in Child Development Biennial Convention in New Orleans, Louisiana, March 17-20, 1977.

Institute for Child Behavior and Development
University of Illinois at Urbana-Champaign

icbd

The Institute for Child Behavior and Development (ICBD) was officially established on July 1, 1975, by the Board of Trustees of the University of Illinois from a merger of the Institute for Research on Exceptional Children and the Children's Research Center.

The ICBD occupies a modern building of 25,000 square feet and three smaller buildings in the College of Education on the Urbana-Champaign campus of the University of Illinois. Its faculty of more than 20 members represents a variety of disciplines and professional areas including special education, psychology, speech and hearing science, linguistics, ethology, sociology, social work, pediatrics, physical education, recreation, educational psychology, and early childhood education. This faculty, aided by more than 150 staff members and graduate students, engages in multidisciplinary research, training, and service on the full range of behavior and development of normal and exceptional children. Experimental day care and nursery school centers in the Institute's main building provide laboratories for the study of normal children. Special classes for very young children with various types of disabilities are operated in another of the Institute's facilities — the Colonel Wolfe School; and field stations for the study of exceptional children are maintained at several education and mental health facilities in Illinois and in other states. The national ERIC system on Early Childhood Education is also housed in the Institute.

Some of the long-term programs of research being conducted include studies of the development of memory, cognition, and language in normal infants and young children; the effects of psychotropic drugs on hyperactive and retarded children; memory and cognitive development of developmentally disabled children; the effects of anxiety on school performance; the effects of intensive early intervention on the development of very young disabled children; language and cognitive development of deaf children; and vocational training of deaf-blind and severely retarded children.

The Institute is under the direction of Robert L. Sprague; Associate Director is Stephen P. Quigley; the central office address is:

Institute for Child Behavior and Development
University of Illinois at Urbana-Champaign
51 Gerty Drive
Champaign, Illinois 61820

ABSTRACT

The present study focused on the executive control of a "cumulative rehearsal, fast-finish" strategy. This experiment (a) extends the notion of the executive function to the case where continued use of a mnemonic routine is a reasonable response to an objective change in an information processing task, and (b) describes (developmentally) the effects of training on the maintenance and generalization of a rehearsal strategy. The results showed that adults spontaneously produced a "cumulative rehearsal, fast-finish" strategy in response to both the assessment and generalization tasks while only two tenth and three twelfth graders did so. All trained subjects maintained the rehearsal routine and showed evidence of transfer. Analyses including adults suggested that the trained subjects generalized routine became more similar to the adult's as grade increased. These findings were supported by interview and observational data.

THE EXECUTIVE CONTROL OF MNEMONIC ACTIVITY

One of the most interesting aspects of memory development is the child's increasingly efficient use of certain strategic behaviors. Flavell (1970) describes this development in terms of those ". . . cognitive activities which could be deliberately undertaken for the purpose of storing and retrieving information" (p. 193). Research has shown that as the child matures, he not only begins to use mnemonic devices spontaneously, but also becomes more capable of flexibily adjusting these strategic behaviors to varied task demands (Belmont & Butterfield, 1977; Bray, 1973; Brown, 1975, 1977; Butterfield & Belmont, 1976; Flavell, 1970, 1971; Kellas & Butterfield, 1971).

Research on mnemonic development has focused only on the child's use of strategic behaviors for meeting the demands of a single task (Brown & Barclay, 1976; Butterfield & Belmont, 1971, 1972, 1976, Flavell, Beach, & Chinsky, 1966). It has not been demonstrated, however, that children develop the ability to adapt a single spontaneous or trained strategic routine to at least two different tasks where the effective mnemonic activity could remain the same (Brown, 1974; Campione & Brown, 1974, 1977).

Mnemonic Development

Literature reviews (e.g., Flavell, 1970) have suggested that over a wide variety of tasks, mnemonic development tends to follow four, not necessarily independent, periods of change. There is an initial mediational deficiency in which the child does not produce the appropriate mnemonic spontaneously, nor can he be trained to do so without an undue amount of time and effort. Furthermore, any induced strategic behavior fails to mediate recall (Kendler, Kendler, & Wells, 1960). This is followed by a period of "mediational inefficiency" (Ryan, Hegion, & Flavell, 1970), where an appropriate mnemonic can be trained or prompted relatively easily but this behavior does not lead to effective performance. Following this is a period of production deficiency, in which prompting or training produces the appropriate skill, which in turn improves performance (Kenney, Cannizzo, & Flavell, 1967). The fourth period of mnemonic development is characterized by the spontaneous use of strategic behavior where effective strategy production results from the child's recognition that the behaviors needed to meet certain task demands are available in his existing repertoire of skills. For storage strategies, this developmental pattern has been found for rehearsal (Flavell, 1970; Hagen, Hargrave, & Ross, 1973; Hagen & Kingsley, 1968, Keeney et al., 1967, Kingsley & Hagen, 1969), the use of organization (Moely, Olson, Halwes, & Flavell, 1969), the use of nonverbal cues (Corsini, 1969, Corsini, Pick, & Flavell, 1968; Ryan et al., 1970), selective attention (Hagen, 1967, 1971, 1972; Hagen & Hale, 1973; Hagen, Meacham, & Mesibov, 1970), and directed or positive forgetting (Bray, 1973; Brown, 1974). The trend from mediational deficiency-inefficiency to spontaneous production has been reported also for the child's use of a variety of retrieval cues (Kobasigawa, 1974; Ritter, Kaprove, Fitch, & Flavell, 1973). In general, these data support the idea that the child gradually acquires the ability to cope with memory demands through an increasingly sophisticated use of mnemonic behaviors.

The child not only acquires additional strategic behaviors as he matures but also becomes capable of using strategies appropriately. The older child both initiates a strategy more readily and uses the selected skill more effectively in response to a task demand. This type of mnemonic flexibility has been demonstrated by the child's use of a single strategy in response to a

unique task. However, a more general case of strategic flexibility would involve the transfer of a successful routine to a second (different) task.

The major purposes of the present research, therefore, are to investigate the development and generalization of strategic behavior, namely, rehearsal, and its selective use in a relatively changed task format.

Executive Functioning

Recently, there has been an increased interest in the development of memory monitoring abilities, especially in the monitoring of strategic mnemonic behaviors (Brown & Barclay, 1976; Butterfield & Belmont, 1976; Butterfield, Wambold, & Belmont, 1973; Flavell, Friedrichs, & Hoyt, 1970; Flavell & Wellman, 1977; Markman, 1973; Masur, McIntyre, & Flavell, 1973). Butterfield and Belmont (1976) describe monitoring as one characteristic of the executive function. They argue that it is the function of the executive to evaluate task demands, select and control strategic abilities, organize, implement, and monitor "executive routines" or strategy sequences, and modify behaviors as the task requirements change. This notion of an "executive" has direct implications for the present research since this study deals with the sequencing of a rehearsal routine through its selective application in a relatively changed task format.

In a recent series of experiments using the pause-time paradigm (Belmont & Butterfield, 1969; Ellis, 1970), Butterfield and Belmont (1976) have reported data which suggests that one capability of the executive's monitoring function was to revise strategic behavior (i.e., a rehearsal sequence) in response to a minimal change in task requirements. To summarize, when normal adults were presented lists of nine different letters they quickly selected an efficient "cumulative rehearsal, fast-finish" strategy (Belmont & Butterfield, 1971, Pinkus & Laughery, 1970, Footnote 4) in response to both a position probe and circular recall task. Furthermore, the same adults not only abandoned the "cumulative rehearsal, fast-finish" strategy when identical stimuli were presented repeatedly in the same order on successive trials, but also rapidly reinstated their strategy with additional changing task demands (Experiment 4).

In a subsequent developmental experiment, Butterfield & Belmont (1976, Experiment 5) presented alternating series of changing and repeated lists of words to subjects aged 10, 12, and 17 years. A circular recall task was used. The data showed that the general response pattern of 12-year-olds paralleled that of adults (17-year-olds). However, these younger subjects did not achieve the precision of pause patterns reported for the adults and they were less flexible at abandoning and reinstating their selected strategy. The results reported for the 10-year-olds suggested that they never adopted a "cumulative rehearsal, fast-finish" strategy and showed little flexibility in adjusting their behavior to changing task demands. These findings, taken as a whole, indicated that mature subjects monitored their memory operations by selecting and revising an effective strategy, and this monitoring ability developed with age.

In the two experiments summarized above, the subjects were required to monitor the effective use of a "cumulative rehearsal, fast-finish" strategy. The subjects discontinued its use when the routine was not needed to maintain high accuracy. The older subjects engaged in a "cumulative rehearsal, fast-finish" strategy when required to remember new information, but terminated this activity once the material was learned.

The tasks used in these experiments required that the subjects either use or not use a (rehearsal) strategy. This task demand is viewed here as a simple type of mnemonic flexibility since a minimum of strategy monitoring is required to maintain high recall. That is, Butterfield and Belmont's (1976, Experiment 5) task requires that the subject merely recognize when to use or not use a rehearsal strategy for a particular list. The task used in the present experiment demands a somewhat more complex type of memory monitoring. It also requires the selective use of a "cumulative rehearsal, fast-finish" routine. That is, here, the subject must recognize not only when to selectively use a rehearsal routine on items within a list, but do so while attempting to maintain rehearsal activity. The subjects, therefore, must continuously monitor their mnemonic effectiveness and maintain the current state of a rehearsal set while selecting new to-be-remembered information. This task requires that the subjects ignore certain material to achieve high recall accuracy.

The Experiment

In the present experiment an attempt will be made to describe in a developmental context (a) the selection of a "cumulative rehearsal, fast-finish" strategy in response to a circular recall task demand, (b) the effects of strategy training on the maintenance of an appropriate rehearsal routine, and (c) the degree to which trained strategic behaviors generalize to a relatively changed task format.

The purposes of this study address two issues. The first issue focuses on the development and generalization of strategic behavior. The evidence to date suggests that children as young as 10 years old do not adopt spontaneously an efficient "cumulative rehearsal, fast-finish" strategy in response to an 8-item (words) circular recall task demand (Butterfield & Belmont, 1976, Experiment 5). Apparently this was a production deficiency since these children responded readily to training (Butterfield & Belmont, 1976, Experiment 7). Furthermore, the specific mnemonic training received affected executive functioning (Butterfield & Belmont, Experiment 7) since trained 10-year-old children abandoned and reinstated their rehearsal activity with repeated and changing list presentations. This research suggests that training affects the executive control of strategic behavior when the task is presented in a maintenance format.

In the present study we intend to see whether (a) the number of children spontaneously selecting and generalizing a "cumulative rehearsal, fast-finish" strategy in response to a circular recall task demand increases with age, (b) children who do not spontaneously select a "cumulative rehearsal, fast-finish" strategy can be trained to use this routine effectively, and (c) the generalized use of a trained "cumulative rehearsal, fast-finish" strategy is age related. That is, as children grow older, the effects of strategy training gradually generalize to other appropriate tasks.

The second issue addressed in the present study concerns an extension of Butterfield and Belmont's (1976) executive control notion. They state that ". . . executive function is exhibited when the subject changes a control process or sequence of control processes as a reasonable response to an objective change in an information processing task" (p. 42). Their research showed that mature subjects could monitor strategic activities on a task which demanded recognizing whether or not to-be-remembered information was learned.

The present investigation will extend this notion since here the maintenance and generalization tasks demand that the subjects not only monitor the effectiveness of a trained or spontaneously produced rehearsal strategy but also that they transfer and selectively use the routine in a different situation. That is, executive functioning is exhibited also when subjects recognize and continue to use a control process or sequence of control processes in response to an objective change in an information processing task demand when such a response is appropriate.

In the present study we will use a 6-item (pictures) circular recall task in the pause-time paradigm. The study is divided into four phases: Assessment, Training, Maintenance, and Generalization. The assessment phase evaluates the subjects' spontaneously selected strategies. Those subjects spontaneously selecting a "cumulative rehearsal, fast-finish" strategy will not be trained. In the training phase, the subjects will be subdivided into two groups: a training and no-training group. This subdivision will be conducted in such a way as to ensure roughly equal assessment (or baseline) performance for each group. Thus, half of those subjects who did not select spontaneously the appropriate strategy will be trained in its use. The no-training group will receive additional trials equal to the number given the trained subjects, however, they will not be instructed. Following either training or no training, both groups will receive a series of maintenance (no instruction) trials.

In the generalization phase, all subjects will be required again to circularly recall six items. The difference between this and the former three phases is that here the six to-be-remembered (TBR) items are dispersed randomly among six to-be-forgotten (TBF) ones. The subjects must, therefore, maintain TBR items through rehearsal while disregarding (forgetting) irrelevant (TBF) information. Thus, rehearsal and positive forgetting must be used in tandem for subjects to maintain high performance.

METHOD

Subjects

The subjects were 62 volunteers chosen from Grades 6, 10, and 12 at the Pesotum Grade School and Tolono High School and nine adults from the University of Illinois at Urbana-Champaign. Excluded from this sample were two children from Grade 6 and one from Grade 10, two of whom were uncooperative and one who took excessive time (1 hour) to complete the first phase of the experiment. Complete descriptive statistics for the remaining 68 subjects are given in Table 1. None of these subjects had prior experience or training in a memory experiment.

- - - - - - - - - - -
Insert Table 1 here
- - - - - - - - - - -

Design

Considering the grade school children, the main design was mixed and represented by the factorial combination of Grade (6, 10, 12) X Group (Training vs. No Training) X Phase. Phase 1, Assessment, consisted of 10 test trials in which the subjects were free to perform on an ad lib basis. The Group variable

was manipulated in the second or Training phase where half of the subjects in each grade were instructed in the use of a "cumulative rehearsal, fast-finish" strategy. In Phase 3, Maintenance, all subjects were given 10 no-instruction test trials. Finally, the Generalization phase consisted of 10 test trials in which the subjects performed on a task presented in a changed format.

In the generalization phase, six TBR items were arranged randomly among six TBF ones. Thus, in this phase, Item Type (TBR vs. TBF) was represented by two levels.

In some analyses, adults were included with the trained grade school children.

The dependent variables were average median pause-time, proportion of items correctly recalled in a circular order, and five observational measures-labeling, rehearsal, cumulative rehearsal, gesturing, and cumulative gesturing. An item was scored as correct only if it were recalled in proper sequence. For the observational measures, the frequency of each behavioral response was summed over subjects within each grade for serial positions 2-6. This was done for each phase and for Trials 1, 5, and 10 separately.

Apparatus

An Automated Wisconsin General Test Apparatus (Scott, 1970) was used. Its primary feature was a 13-window display panel interfaced with solid state recording equipment. Each window was a 5 x 5 cm rear projection plexiglass panel with a shutter mounted on back. The shutter was operated, thus exposing a stimulus for 1.0 second, when the subject pressed the window. The windows were arranged in two 6-window rows with the 13th window centered below the second row. The windows were 1.90 cm apart. Mounted directly below the 13th window was a small yellow light which signaled the start of each trial. The second row of windows was blocked during the assessment, training, and maintenance phases.

Pause-times (in hundredths of seconds) were recorded and printed automatically. The subjects' accuracy scores were recorded by the experimenter. A Sony 3650 video tape recorder was used to record the observational data. This system included two cameras, one focused on the display panel and the other on the subject, a special effects generator and two WV-950 Panasonic monitors. A Sony TC-92 tape recorder was used to record the post-test interview.

The entire apparatus was housed in a two-room experimental suite located in a mobile home. The subject, experimenter, display panel, and video cameras occupied one room, while the programming equipment and video tape recording system were hidden from view in the other.

Stimulus Materials

The stimulus pool consisted of 360 different colored pictures of common objects which, in previous research and pilot work, were shown to be labeled easily by preschool children. The following stimulus slides were made for each phase of the experiment: Assessment-13, 6-item slides depicting objects from the same conceptual category with different categories represented on each slide; Training--11, 6-item slides depicting objects from different conceptual categories. It was necessary to use pictures from different categories

since it was impossible to locate multiple exemplars from varying categories without having redundant items. For the generalization phase, 13, 12-item slides depicting six different exemplars from two different conceptual categories, were made. The categories represented in each slide were selected so that the exemplars of each category were identified easily. The six items from each category were assigned randomly to each serial position. The only restriction on this assignment was that a TBR and TBF item appeared in the last position on half of the trials.

A stimulus card, 61 x 18 cm, containing 12 items from two categories (animals and toys) was constructed from 8.89 cm square pictures. These pictures were arranged randomly on the card in two equal rows.

Procedures

In the sample of 68 subjects tested, two tenth graders, three twelfth graders, and all 9 adults were identified as spontaneous producers of a "cumulative rehearsal, fast-finish" strategy. None of these subjects received later training. For the other 54 subjects, 9 each at Grades 6, 10, and 12 were assigned to either the training or no-training group. These groups were matched roughly on overall pause-time, circular recall accuracy, and sex.

The same experimenter tested each subject individually. The subjects were seen for two experimental sessions (on different days) each lasting 25-35 minutes. Session 1 consisted of strategy assessment and Session 2 of training, maintenance, and generalization trials.

Each subject was seated in front of (facing) the display panel and told that he would see some pictures to remember. The subjects also were told that they would receive $2.00 for participating. The specific procedures are listed below by session for each phase.

Session 1--Assessment. Each subject received three warmup and 10 test trials where one trial was defined as the self-paced presentation and circular recall of six different items. Thus, the child viewed pictures 1-6 in sequential order (from left to right) and attempted to recall them beginning with item 5, then 6, and finally 1-4. A new picture appeared when the subject pressed a window. Following the presentation of the sixth picture, the subject was required to press the 13th window when ready to begin recall. If a subject did not complete a recall sequence, the experimenter waited 30 seconds and then probed to determine whether or not any additional pictures could be remembered. A trial was terminated when either all six pictures had been recalled or when the subject indicated that he could not remember any more.

The three warmup trials consisted of one demonstration trial performed by the experimenter and two by the subject. This demonstration emphasized the required circular recall order, not the acquisition strategy to be used. Each subject was told that he could take as much time as he wanted since a new picture would appear only when he pressed a window. Also, each subject was told that he could do anything he wanted to help himself remember the names of the pictures. After the demonstration, the experimenter answered any questions regarding the procedure. The subject then was told to begin the next warmup (and subsequent) trial(s) when the small yellow light on the panel flashed. Ten test trials, which were videotaped, followed this warmup.

Session 2--Training. The task used for training was the same as that used in assessment except new stimuli were presented and only one warmup-demonstration trial was given. Also, the stimuli presented in each trial were from different categories.

The procedures for the training group were as follows. On the warmup trial the experimenter demonstrated a "cumulative rehearsal, fast-finish" acquisition strategy by exposing the first four pictures, labeling and including each new picture in a rehearsal set. Picture names were added to the set up through item #4. After the first four items were rehearsed cumulatively three times, the experimenter pointed to and exposed the fifth and sixth pictures, labeling, but not rehearsing them. The experimenter then said quickly (pointing to the appropriate windows) the names of these last two items followed by the first four. The subject was asked for questions and reminded to press window #13 when ready to recall. The ten training trials which followed were identical to this demonstration except the subjects were required to use the rehearsal routine described above.

The procedures for the no-training group were identical to those used in assessment. The stimuli were the same as those used for the training group.

Session 2--Maintenance. In maintenance, both groups were given 10 additional no institution (maintenance) trials. The spontaneous subjects (except the adults) were treated like the no-training group. These maintenance trials were videotaped and after the 10th trial the subject was given a 5-minute break.

Session 2--Generalization. The procedures which follow applied to all subjects. The recall requirements for the generalization task were exactly the same as those in the assessment, training, and maintenance phases. However, the task demand was changed. Each subject self-presented 12 different pictures. Half of the pictures (six) were from one conceptual category and half (six) from another. The subject was required to circularly recall six exemplars from one of the categories. The experimenter announced the category of TBR pictures before each trial began. The subject was instructed in the meaning of category membership and then given three warmup and 10 test trials.

After the break, the subject was reseated in front of the apparatus. The 61 x 18 cm stimulus card was presented and the experimenter explained the notion of category membership. The experimenter then demonstrated the circular recall of six exemplars from one category. The subject was then asked to circularly recall the exemplars of the other category. Throughout this presentation, the experimenter emphasized that the subject would be required to remember only the exemplars (TBR items) from one category. The subject was told that the other category members (TBF items) could be forgotten since he would not be asked to recall them. The subject was then oriented towards the display panel and told to begin the warmup trials when the yellow light flashed.

Three warmups were given and procedural errors were corrected. The experimenter did not instruct or prompt the subject to use a "cumulative rehearsal, fast-finish" strategy on TBR information. The subject was told that he could do anything he wanted to aid memory. The warmup was followed by 10 test trials which were videotaped. After the 10th test trial each subject was interviewed.

Post-test Interview

In the post-test interview, each subject was asked a number of questions to determine whether or not he was aware of his strategy usage during generalization. The grade schoolers answers were tape recorded.

Observational Measures

The observational measures were recorded from the videotapes of the assessment, maintenance and generalization phases' test trials. The purposes of these measures were to determine whether or not observed strategic behaviors corresponded to pause-time patterns and to extend earlier findings (i.e., Flavell et al., 1970) to the context of the pause-time paradigm. Further, since the present investigation deals with the selective use of a specific rehearsal strategy, the observational data could support conclusions based on the pause patterns found for TBR and TBF information during the generalization test phase.

In order to check the reliability of the observed behaviors, two judges independently scored Test Trials 1, 5, and 10 for four subjects in the training and no-training groups in the assessment, maintenance, and generalization phases of the experiment. The interrater reliability coefficient (IRR) was computed as:

$$\text{IRR } (\%) = \frac{\text{Total number of interjudge agreements}}{\text{Total number of observed behaviors}} \times 100;$$

where,

Total number of interjudge agreements =
Total number of observed behaviors -
Total number of disagreements.

Disagreements occurred when the judges recorded different numbers of behaviors or classified the behaviors differently.

RESULTS AND DISCUSSION

In the initial set of analyses, three dependent variables were considered: Average median pause-time, proportion of items correctly recalled in a circular order, and proportion of items correctly recalled ignoring order. As the obtained results for the latter two variables were similar, only the analyses for ordered recall (henceforth referred to as proportion correct) will be presented. Further, in a preliminary set of analyses, only one higher order interaction involving sex was found reliable.[2] Accordingly, in the reported analyses, sex was not included as a factor.

The results are reported for analyses involving phases and item type separately. Adults were included in some analyses since their assessment phase pause-time pattern defined an "optimal" rehearsal strategy for achieving high recall accuracy, thus an appropriate routine to be trained. Also, the adults' generalization phase data established that task as a useful one for assessing transfer effects since their pause pattern was highly similar to that found in assessment (Brown, 1977). Their data, while serving an illustrative purpose, cannot be compared directly with the younger (untrained) subjects since the adults were drawn from a select population.

Analyses Involving Phases

Assessment phase analyses. Inspection of the assessment phase pause patterns revealed that while the adults spontaneously produced an effective (92% correct recall) "'cumulative rehearsal' (items 1-4), 'fast-finish'" (items 5 and 6) strategy, only two tenth graders and three twelfth graders did so.

Considering nonspontaneous subjects, an analysis of assessment phase performance was done to (a) check the original comparability of the training and no-training groups, and (b) determine whether spontaneously selected strategies differed among grades. A Grade (3) X Group (2) X Serial Position (6) mixed analysis of variance (ANOVA) was conducted on the assessment phase performance. The groups were assumed to be equitably matched since no Group, Grade X Group, or Group X Serial Position effects were found for either pause-time or proportion correct, all Fs < 1.0.

Assessment phase pause patterns suggested that the selected strategic routines for sixth, tenth, and twelfth graders were similar since the Grade and Grade X Serial Position effects were nonsignificant, both Fs < 1.0. The typical pattern showed low, relatively constant pauses after items 1-5 with a long pause after item 6. Post hoc analyses (Scheffé, 1959) showed that the pause-times after each of items 1-5 were significantly less than after item 6, all F's > 18.0, p < .05 for all.

The effectiveness of these subjects' behaviors varied, however, with grade. The Grade and Grade X Serial Position effects were reliable for proportion correct, F (2,48) = 21.90, and F (10,240) = 5.77, respectively, p < .001 for both. Post hoc analyses indicated that tenth ($\bar{X}$ = .84) and twelfth ($\bar{X}$ = .84) graders recalled significantly more items than sixth graders ($\bar{X}$ = .60), F' (2,48) = 10.95, p < .05. Post hoc tests revealed that while both the tenth and twelfth graders' recall was significantly higher than sixth graders' at serial position 1-4, smallest F' (10,240) = 20.33 p < .05, there were no grade differences at positions 5 and 6.

These proportion correct data replicate earlier research which showed that developmental recall differences occur in the primacy, or earlier, portion of the serial position curve (i.e., items 1-4 here, Ellis, 1970). The primacy differences reported here and elsewhere are assumed to be attributed to a rehearsal deficit in the young subjects. Note, however, that this proposed rehearsal deficit was not evident from the data presented for pause-times. It appears that while the older and younger subjects pause patterns were similar, the older subjects activities facilitated recall more than the behaviors adopted by the sixth graders.

In general, these results are surprising given Butterfield and Belmont's (1976, Experiment 5) data. They reported that seventh graders spontaneously adopted a "cumulative rehearsal, fast-finish" strategy on an 8-item circular recall task, while here on a 6-item task, tenth and twelfth graders did not. The only apparent differences between the two studies, other than the number of stimuli used, are that Butterfield and Belmont presented words whereas pictures were used here and an explicit recall readiness instruction was given in the present experiment. It is not clear from the present data how these differences could account for the discrepant developmental trends found. One reasonable explanation would be that the small number of pictures presented

here did not prompt the older subjects to use a "cumulative rehearsal, fast-finish" strategy since they could maintain high recall without using such a routine. Nevertheless, without further study, it can only be stated that the tenth and twelfth graders' adopted strategy was more effective than the sixth graders', expecially for the first items seen.

Overall ANOVA for pause-time. Consider next the overall Grade (3) X Phase (3) X Group (2) X Serial Position (6) analysis designed to evaluate the effects of training on the maintenance and generalization of a "cumulative rehearsal, fast-finish" strategy.

The main effects for Group F (1,48) = 10.77, $p < .02$, Phase F (2,96) = 8.40, $p < .001$, and Serial Position F (5,240) = 36.60, $p < .001$, were significant as were the first order interactions of Group X Phase, F (2,96) = 13.60, Group X Serial Position, F (5,240) = 21.37, and Phase X Serial Position, F (10,480) = 45.88, $p < .001$ for all. Each of these effects were involved in the significant higher order interaction of Group X Phase X Serial Position, F (10,480) = 31.22, $p < .001$. This effect is illustrated in Figure 1, panels a-c.

- - - - - - - - - - -
Insert Figure 1 here
- - - - - - - - - - -

In panels a and b, it is seen that the originally matched groups differed in their maintenance phase routines. A Grade (3) X Group (2) X Serial Position (6) mixed ANOVA on maintenance phase pause-times revealed a significant Group X Serial Position interaction, F (5,240) = 55.81, $p < .001$. Trained subjects showed increased pauses after items 1-4, and rapid responses after items 5 and 6 while untrained subjects tended to respond with short, constant pauses throughout. These data support the conclusion that trained subjects maintained a "cumulative rehearsal, fast-finish" strategy without being prompted to do so.

In the generalization phase, panel c, the training group ($\bar{X}$ = 3.19 secs.) continued to pause longer than the no-training group ($\bar{X}$ = 1.56 secs.). To verify this result, a Grade (3) X Group (2) X Serial Position (6) mixed ANOVA was conducted which indicated that the Group, F (1,48) = 14.73, and Group X Serial Position effects, F (5,240) = 4.99, $p < .001$ for both, were reliable. Post hoc analyses on the Group X Serial Position effect showed that trained subjects paused significantly longer than untrained subjects at serial positions 4, 5, and 6, smallest F' (5,240) = 19.76, $p < .05$, while the pause-time differences were nonsignificant at positions 1, 2, and 3. These results support the contention that instruction affected the trained subjects' generalization phase behaviors.

An additional important finding is suggested by comparing panels b and c, and a and c of Figure 1. In panels b and c it is seen that the trained subjects modified their pause pattern from the maintenance to generalization phase. A Grade (3) X Phase (2--maintenance/generalization) X Group (2) X Serial Position (6) mixed ANOVA revealed a significant Group X Phase X Serial Position interaction, F (5,240) = 36.35, $p < .001$. This effect supports the visual impression that the trained subject's generalization phase pause pattern differed from that found during maintenance in at least two ways. First, these subjects continued to pause increasingly longer after items 1-4, but their their pause-times after item 4 were significantly shorter, F' (5,240) = 282.27, $p < .001$, in generalization; and second, in the generalization phase, their pause-times after items 5 and 6 were significantly longer, F' (5,240) = 51.00, and F' (5,240) = 42.39, respectively, $p < .001$ for both, than in maintenance.

A comparison of panels a and c shows further that the trained subjects' generalization phase performance was also different from their assessed behavior. A Grade (3) X Phase (2--assessment/generalization) X Group (2) X Serial Position (6) mixed ANOVA revealed a significant Group X Phase X Serial position interaction, F (5,240) = 3.43, $p < .005$. Follow-up tests showed that the trained subjects' pause-times were significantly longer in generalization at serial positions 3, 4, and 5, smallest F' (5,240) = 12.10, $p < .05$, than in the assessment phase. A similar comparison at item 6 was nonsignificant.

It appears from the results reported above that the effects of training are understood not only by comparing the maintenance and generalization phases, but also by describing differences between assessed and generalized pause-times. Therefore, these findings address two issues. First, training effects transferred to a task presented in a somewhat changed format, yet the form of the generalized pause pattern was somewhat different than that trained; and second, the generalized effects of training were also evident from a comparison of the assessment and generalization phases.

In the results reported thus far, training did not appear to differentially affect the performance of sixth, tenth, or twelfth graders. However, a reliable Grade X Phase X Group interaction, F (4,96) = 2.57, $p < .04$, was found. This second order interaction, while being the only effect involving grade, revealed a developmental point of interest. That is, in a Phase (2-maintenance/generalization) X Serial Position (6) ANOVA, the trained sixth graders' generalization phase pause-times ($\bar{X}$ = 2.67 secs.) were significantly less than those reported for maintenance ($\bar{X}$ = 4.32 secs.), F (1,8) = 21.06, $p < .02$. In similar analyses involving trained tenth and twelfth graders, the phase main effects were nonsignificant.

These results suggest that among the training groups, sixth graders did not continue to use as active a mnemonic routine as the older subjects when the task format was slightly changed. These data, however, are only weak evidence of differential effects of training over grades.

Overall ANOVA for proportion correct. The effectiveness of training a specific rehearsal strategy was evaluated by a Grade (3) X Phase (3) X Group (2) X Serial Position (6) mixed ANOVA for proportion correct.

The main effects of Grade, F (2,48) = 20.36, Group, F (1,48) = 10.71, and Serial Position, F (5,240) = 32.24, $p < .001$ for all, were reliable. Post hoc analyses indicated that subjects in Grades 10 ($\bar{X}$ = .82) and 12 ($\bar{X}$ = .83) recalled significantly more items than did sixth graders ($\bar{X}$ = .61), F' (2,48) = 30.62, $p < .01$. The group effect showed that the trained subjects' ($\bar{X}$ = .81) recall was reliably higher than the untrained ($\bar{X}$ = .70). Also, recall was significantly better at serial positions 1, 5, and 6, than at positions 2-4, smallest F' (5,240) = 13.85, $p < .05$. This finding replicates previous research in that items which, by task demand, need to be recalled first, are remembered better than those which need to be recalled last.

The first order interactions of Grade X Serial Position, F (10,240) = 5.21, Group X Phase, F (2,96) = 9.76, Group X Serial Position, F (5,240) = 3.89, and Phase X Serial Position, F (10,480) = 4.89, $p < .002$ for all, were also significant.

Consider first the developmental effect associated with the Grade X Serial Position interaction as illustrated in Figure 2. It is seen that for each

- - - - - - - - - - -

Insert Figure 2 here

- - - - - - - - - - -

grade, the proportion of items correctly recalled decreased significantly from positions 1 to 4, smallest F' (10,240) = 63.67, $p < .01$, yet remained high at 5 and 6, and that the difference between the recall of tenth and twelfth graders in comparison to the subjects in Grade 6, varied over serial positions 1-6. The post hoc analyses showed that subjects in Grades 10 and 12 recalled significantly more items at each serial position than did sixth graders, smallest F' (10,240) = 12.04, $p < .05$, and that this recall difference was greatest for items at positions 1-4. These results replicate earlier research findings (see Ellis, 1970, for a review) which have shown that developmental recall differences are most evident for information which needs to be maintained longest through rehearsal.

Next consider the results associated with the significant Group X Phase X Serial Position interaction, F (10,480) = 4.38, $p < .001$, which is depicted in Figure 1, panels d-f.

Panels d and e show that while the groups did not differ in the assessment phase, the proportion of items correctly recalled during maintenance varied at each serial position. A Grade (3) X Group (2) X Serial Position (6) mixed ANOVA on the maintenance performance revealed a significant Group X Serial Position interaction, F (5,240) = 8.47, $p < .001$. Post hoc analyses showed that subjects trained to use a "cumulative rehearsal, fast-finish" strategy recalled significantly more items at each serial position than did untrained subjects, smallest F' (5,240) = 20.15, $p < .01$, and that the recall differences were greatest for items at positions 1-4.

This conclusion was supported further by the results of a Grade (3) X Phase (2--assessment/maintenance) X Group (2) X Serial Position mixed ANOVA since a significant Phase X Group interaction, F (1,48) = 42.09, $p < .001$, was found. While the training ($\bar{X}$ = .76) and no-training ($\bar{X}$ = .77) groups' recall was similar in the assessment phase, it varied during maintenance ($\bar{X}$ = .87 and .66 for the training and no-training groups, respectively).

Note, however, that no Grade X Phase or Grade X Group X Phase effects were found. Thus, while instruction improved the recall of trained subjects, the effects were similar for each grade. In addition, the Grade main effect was also significant, F (2,48) = 18.51, $p < .01$, indicating that the overall assessment phase performance differences between sixth, tenth, and twelfth graders remained even within the training group.

In the generalization phase, (see panel f, Figure 1) the training group ($\bar{X}$ = .79) continued to recall more items than the no-training group ($\bar{X}$ = .68). A Grade (3) X Group (2) X Serial Position (6) mixed ANOVA conducted on the generalization performance verified this group difference, F (1,48) = 4.24, $p < .05$, and showed further that the Group X Serial Position interaction was significant, F (5,240) = 3.09, $p < .01$. Again, post hoc analyses indicated that trained subjects recalled more items at each serial position than untrained subjects and the differences were significant at positions 2, 3, and 4, smallest F' (5,240) = 11.05, $p < .05$, but not at 1, 5, and 6. These results, together with those reported for pause-times, suggest that the generalized

routine used by trained subjects was more effective than the strategy adopted by untrained subjects.

The analysis of generalization performance also indicated a reliable Grade effect, F (2,48) = 8.26, $p < .01$. Post hoc analyses showed that both tenth ($\bar{X} = .80$) and twelfth ($\bar{X} = .83$) graders recalled significantly more items than did sixth graders ($\bar{X} = .58$), F' (2,48) = 10.95 and 14.14 respectively, $p < .05$ for both. Furthermore, there was a significant Grade X Serial Position interaction, F (5,240) = 2.19, $p < .02$. Subsequent follow-up tests showed that tenth and twelfth graders recalled more items than the sixth graders at each serial position, smallest F' (5,240) = 11.17, $p < .05$, and the differences were greatest at positions 1-4. These results suggest that the overall developmental recall differences reported for the assessment and maintenance phases were again apparent in the generalization phase.

In general, the results reported for pause-time and proportion correct support the conclusions that (a) a trained "cumulative rehearsal, fast-finish" strategy was maintained and used by sixth, tenth, and twelfth graders, (b) considering only pause-time, weak evidence suggested that the effects of training transferred to varying degrees over Grades 6, 10, and 12, (c) trained subjects were more effective in meeting the generalization task demands than were untrained ones, and (d) the initial developmental recall differences between the older subjects and the sixth graders remained even after training and in the generalization phase. Therefore, it may be assumed that even though the sixth graders used the trained strategy, they were not able to use it effectively enough to eliminate the initial developmental recall differences. The proportion correct results supported this interpretation since the trained sixth graders' recall was lower than the older subjects' in both the maintenance and generalization phase but higher overall (although not significantly) than that found for untrained sixth graders.

Analyses including adults. The next set of analyses involving phases included the training group plus adults (T + A). These analyses were done since they (a) address the developmental question of whether or not the generalized use of a trained routine differs across grades in comparison to an adult norm, and (b) provide an in-depth look at the effects of training on generalization task performance. Accordingly, a T + A (4--Grades 6, 10, and 12 and adults) X Phase (2--assessment/generalization) X Serial Position (6) mixed ANOVA was conducted on the pause-time and proportion correct data.

Considering pause-time, the main effect for T + A was nonsignificant. This result indicated that subjects in Grades 6, 10, and 12 and adults did not differ in the overall amount of time spent pausing after each stimulus item. However, the T + A factor interacted significantly with Phase, F (3,32) = 4.84, $p < .01$, and Serial Position, F (5,160) = 12.67, $p < .001$. Additionally, each of these effects were involved in the T + A X Phase X Serial Position interaction, F (15,160) = 1.83, $p < .03$. This second order effect is illustrated in Figure 3.

- - - - - - - - - - -

Insert Figure 3 here

- - - - - - - - - - -

This figure shows that the adults not only spontaneously selected a "cumulative-rehearsal, fast-finish" strategy in response to a 6-item circular task, but also generalized and used the routine in a changed task format. The

data for the sixth, tenth, and twelfth graders are quite different and represent two interesting findings. First, as reported previously, the training group did not initially adopt the routine selected by the adults; and, second, the generalized routine used by the twelfth graders was most like the adults, followed in similarly by the tenth graders' performance. The sixth graders' pause pattern was the least similar to the adults'.

A comparison of the assessment and generalization phases suggest that following training and maintenance, the tenth and twelfth graders modified their strategic behaviors in a more systematic way than did the sixth graders. These data suggest that the magnitude of the transfer effect was reflected in the degree of similarity between the shape of each grade's pause pattern and that found for the adults. Post hoc tests within the generalization phase indicated that the grade schoolers' pause-times did not differ significantly from the adults' at serial positions 1 through 3. Analysis at position 4 showed, however, that the sixth graders' pause-time was significantly shorter than the tenth and twelfth graders', smallest $\underline{F}'$ (15,160) = 9.95 $\underline{p} < .05$. At position 5, a similar analysis revealed that the sixth graders' pause-time was significantly shorter than the twelfth graders, $\underline{F}'$ (15,160) = 10.70, $\underline{p} < .01$, while the tenth graders paused significantly longer than the adults, $\underline{F}'$ = (15,160) = 23.11, $\underline{p} < .01$. The sixth and tenth graders' pause-times at serial position 6 were significantly longer than the adults', $\underline{F}'$ (15,160) = 11.67 and 24.23, respectively, $\underline{p} < .01$ for both. Furthermore, the twelfth graders' pause-time at position 6 was significantly shorter than the tenth graders', $\underline{F}'$ (15,160) = 16.18, $\underline{p} < .05$, but not reliably different from the sixth graders or adults. These results confirm the visual impression that the older the subjects, the more similar their pause patterns were to the adult norm.

Analyses of the proportion correct data suggested a pattern of results similar to those reported for the grade school children alone. That is, the older the subject (adults, Grades 10 and 12 vs. Grade 6) the more items recalled, especially in the primacy portion (items 1 - 4) of the serial position curve.

To summarize, these results suggest that (a) the sixth graders' generalized strategy was least like the adults' as well as the least effective for maintaining high recall, (b) the twelfth graders' generalized routine was the most similar to that found for adults, and (c) the tenth graders' generalized strategic behaviors, while facilitating recall, were less similar to the adults' than the twelfth graders'. This latter finding implies further that the tenth graders adjusted their response pattern during generalization by increasing their pause-times at items 5 and 6 to maintain high accuracy.

These data support the conclusion that training affected the executive monitoring of strategic behaviors. The analyses including the adults suggested these effects were apparently greatest for tenth and twelfth graders.

Analyses Involving Item Type

The analyses of the item type data address two issues: (a) selective use of strategic mnemonic behavior, and (b) the generalized effects of training on the selective use of a "cumulative rehearsal, fast-finish" strategy. To evaluate these issues, a Grade (3) X Group (2) X Item Type (2) X Serial Position (6) mixed ANOVA was done for the pause-time data.

The ANOVA revealed that the Grade main effect was nonsignificant, F (2,48) = 1.06, $p < .36$, as were all interactions with Grade. However, the Group F (1,48) = 12.81, Item Type, F (1,48) = 35.10, and Serial Position effects, F (5,240) = 7.94, $p < .001$ for all, were significant. Further, each of these significant effects were involved in a reliable Group X Item Type X Serial Position interaction, F (5,240) = 4.71, $p < .001$. Figure 4 illustrates this effect. It can be seen that for TBR items, trained subjects paused significantly longer at serial positions 3, 4, 5, and 6 than did untrained subjects, smallest F' (5,240) = 20.39, $p < .01$. Also, the post hoc tests indicated that the no-training group did not pause significantly longer after TBR than TBF items while the trained subjects did so at serial positions 2, 3, 4, 5, and 6, smallest F' (5,240) = 14.21, $p < .05$.

- - - - - - - - - - - -
Insert Figure 4 here
- - - - - - - - - - - -

These results indicated that "cumulative rehearsal, fast-finish" training affected generalization phase performance in that trained subjects clearly differentiated TBR from TBF items while untrained subjects did not.

Consider the above in light of the earlier results, which showed that (a) while the trained sixth graders' generalized performance was different from that found for untrained subjects, their pause pattern was the least similar to the adult norm, (b) these same sixth graders' recall was significantly below that found for tenth and twelfth graders, and (c) all trained subjects (regardless of grade) paused reliably longer after TBR than TBF items. Taken together, these results suggest that training affected the sixth graders in a "general," non-specific way since their item type treatment was similar to that found for older trained subjects, yet quite different than that reported for untrained subjects.

The findings discussed above suggest that training a "cumulative rehearsal, fast-finish" strategy affected the executive function in two important ways. First, training affected the manner in which subjects treated TBR and TBF items. This result indicates that item selection, as a mnemonic behavior controlled by the executive, was modified by training. Second, since no grade effects or interactions involving grades were found in the Item Type analyses, training affected each grade's selective behavior equally. This latter point is especially relevant when considering the sixth graders since training affected their generalized performances but not in a way comparable to that found for the older subjects.

In general summary, the analyses involving phases and item type suggested that while the adults spontaneously adopted a "cumulative rehearsal, fast-finish" strategy and generalized it to a changed task format, the performance of the trained and untrained subjects in Grades 6, 10, and 12 presented a different picture. For the nine subjects in each grade who were not trained, the results showed a generally decreasing trend in average median pause-times over phases. Within each phase, especially during maintenance and generalization, the untrained subjects' pause patterns were low and variable. Additionally, in comparison to the trained subjects in the maintenance and generalization phases, the no-training groups' recall was lower at each serial position. For the training group, the maintenance phase data revealed that all subjects, regardless of grade, continued to use the trained routine which improved their recall. In the generalization phase the trained subjects modified their

maintenance phase patterns. Based on analyses including adults, the modified patterns showed that the sixth graders' generalized pattern was variable but generally increasing over serial positions. The tenth and twelfth graders' pause patterns and recall data suggested that their generalized strategic routine was used effectively and further, the similarity of the transferred routines became more similar to an adult norm as grade increased.

The item type analyses supported and extended the results reported for phases in that training affected the selective treatment of TBR items. The training group not only spent more time than the no-training group on TBR items but also selectively distributed their responses differently over serial positions. The untrained subjects' response patterns for TBR and TBF items were similar--both being flat.

Observational Data

Preliminary inspection of the data revealed no differences in the observed response patterns over Trials 1, 5, and 10, therefore the behavioral frequencies were averaged for serial positions 2-6. The interrater reliability (IRR) was 82%.

The average number of responses per subject was plotted for all five behaviors and presented in Figure 5 (training group) and 6 (no-training group). These figures show that each observed behavior occurred approximately equally often for both trained and untrained subjects in the assessment phase. These data support the pause-time and proportion correct data reported earlier which also suggested no differences between groups during assessment.

- - - - - - - - - - - - - - -
Insert Figures 5 and 6 here
- - - - - - - - - - - - - - -

In the maintenance phase, observed cumulative rehearsal and cumulative gesturing responses clearly differentiated trained from untrained subjects. Figure 5 shows that the frequencies and patterns of overt cumulative rehearsals were comparable for Grades 6, 10, and 12. These results support data previously reported in that trained behaviors were maintained by all grades on a task identical (albeit with different stimuli) to the training task.

In reference to cumulative gesturing, Figure 5 shows that over serial positions 2-4, sixth graders overtly responded more frequently than tenth and twelfth graders. The subjects in Grade 12 overtly used a cumulative gesturing strategy less often than either sixth or tenth graders. By comparison to untrained subjects (Figure 6), training increased the observed frequency of this behavior. The other behaviors provided no insights into strategy usage.

In the generalization phase, the behavior of prime interest was cumulative rehearsal since it comprised the major part of the trained routine. As is illustrated in Figures 5 and 6, the trained subjects were observed cumulatively rehearsing more frequently than the untrained ones. The frequencies and patterns for this behavior were roughly equal for Grades 6, 10, and 12 in the no-training group but different in both dimensions for the training group. Specifically, the trained twelfth graders were observed cumulatively rehearsing more than the tenth who in turn, overtly responded more than the sixth graders.

These data, in comparison to those reported for untrained subjects (Figure 6), suggest that the observed behaviors were used by the trained subjects

in the generalization phase on a task similar to that presented during maintenance, but the form of this usage was related to grade. The observed frequencies of labeling, rehearsal, gesturing, and cumulative gesturing did not differentiate the grades or groups.

In general, the observational measures showed that the training and no-training groups were matched roughly in the assessment phase and that a trained "cumulative rehearsal, fast-finish" strategy was maintained by all grades and subsequently used (to varying degrees) on a transfer task. With reference to cumulative rehearsal, the generalization phase performance of subjects in Grades 6, 10, and 12 suggested that twelfth grades transferred and used the trained routine more than did the tenth graders. The subjects in Grade 6 did not overtly use the trained response pattern and showed decreasing response frequencies over serial positions. Furthermore, throughout the generalization phase, for both groups and all grades, only one subject rehearsed one TBF item.

Post-test Interview

The primary purpose of this interview was to determine whether or not the subjects were aware of their strategy usage. Originally, each subject's responses to five questions were recorded for sixth, tenth, and twelfth graders. However, since all subjects said it was not hard to remember the picture names and were not distracted by TBF items, only the responses to the following question are reported: "Suppose you could do anything you want, what do you think would be the best way to remember the names of pictures like the ones you just saw?"

The subjects' responses were classified as either active or passive. A subject's verbal response was classified as active if it indicated mnemonic usage. Examples of active responses were, "I would write them (picture names) down," or I would say their names over to myself in order," etc. Two types of passive responses were identified: (a) no verbal response at all, or (b) if a verbal response indicated no mnemonic usage. An example of a passive verbal response was, "I would just look at them (pictures)."

Table 2 presents the proportion of subjects responding actively and passively for each grade separated by group. As is seen, the greatest proportion of subjects responded actively (.93) independent of grade or group.[3] A Grade (3) X Group (2) chi square test on the number of subjects responding actively was nonsignificant, $\chi^2_5 = 3.97$, $p < .10$, suggesting that trained and untrained subjects in each grade were aware of their mnemonic activities. The data for sixth graders, however, are of particular interest since the expressed awareness of these subjects was not translated into an effective response pattern. That is, even though the sixth graders verbalized "active" types of responses, their circular recall data did not indicate effective application. Further, in reference to Grades 10 and 12, it is seen from the post-test interview that these subjects' awareness of their active strategic behavior was associated with their actual performance.

- - - - - - - - -

Insert Table 2 here

- - - - - - - - -

CONCLUSIONS

This experiment provided information concerning a number of developmental issues related to the executive control of strategic mnemonic activities. First consider the adult data. These data served two important functions since they (a) suggested a strategy to be trained to nonspontaneous children, and (b) established that the generalization situation was an appropriate transfer test as both the assessment and generalization task evoked the same mnemonic routine in mature memorizers (Brown, 1977). More importantly, the adult data extends our knowledge of efficient executive control. Butterfield and Belmont (1976) have shown that adults chose to abandon a strategy when it was no longer needed to maintain high recall. Here it was shown that flexible control also includes the continued use of a strategy in a new situation where such use was appropriate; thus, the generalization of an adopted control process or sequence of control processes. It is apparent, therefore, that both types of behavior are a necessary part of the flexible executive control of strategy utilization.

Consider next the performance of sixth, tenth, and twelfth graders in the assessment phase. This phase was intended to describe the development of a spontaneously produced "cumulative rehearsal, fast-finish" strategy. However, since only two tenth and three twelfth graders produced the routine meaningful comparisons among grades and groups were prohibited. The strategy selection data did not support Butterfield and Belmont's (1976) results.

It is not clear how the differences between the present study and that of Butterfield and Belmont (1976) could account for the descrepant age-related behaviors found. One explanation could be that the present task did not prompt tenth and twelfth graders to use a "cumulative rehearsal, fast-finish" strategy since they could maintain a high recall accuracy for 6-items without such an effort. However, this is not a reasonable assessment as adults spontaneously adopted the optimal strategy. The fact is that the children in Grades 10 and 12 did not think to use a "cumulative rehearsal, fast-finish" strategy but adults did. The question of why remains.

In the training phase, all instructed children easily acquired a "cumulative rehearsal, fast-finish" strategy. Thus, following a relatively brief training period, sixth, tenth, and twelfth graders effectively produced the instructed rehearsal routine.

During the maintenance phase, the pause-time data suggested that all instructed children continued to use the trained "cumulative rehearsal, fast-finish" routine. However, by considering the proportion of items correctly recalled, three developmental factors were revealed: (a) although the pause patterns and observed behaviors indicated that all grades were using the same mnemonic routine, the recall data showed that trained tenth and twelfth graders remembered more items than trained sixth graders, (b) because the proportion of items correctly recalled by tenth and twelfth grade children was high in the assessment phase, training only slightly improved their accuracy, and (c) while the trained sixth graders showed a 19% recall improvement from the assessment to maintenance phase, their overall performance was still below that found for the older children but above that reported for untrained sixth graders.

The improved performance found for trained children in the maintenance phase suggested that these children, especially the sixth graders, were production as opposed to mediation deficient in the use of a "cumulative rehearsal, fast-finish"

routine. That is, even though these children did not spontaneously adopt such a routine they could use it effectively, thus showing improved recall (Flavell, 1970; Kenney et al., 1967). For the two older grades, this "production deficiency" interpretation was limited since their recall performance was not improved substantially by training.

These data replicated other developmental research in that a trained mnemonic routine was maintained by all children without further instruction or prompting (Brown 1974; Butterfield, et al., 1973). Note that other relevant research has shown that the maintenance of a trained strategic behavior was related to developmental level (Flavell, 1970; Kenney, et al., 1967). That is, younger children tended to abandon a trained mnemonic activity if (a) there was a long delay between training and a maintenance test, or (b) the experimenter did not continuously prompt the child to use a strategy. In the present paper the youngest children were found to maintain the trained strategy. This finding was not necessarily supported by previous research. However, the sixth graders were relatively old by comparison to the subjects in other studies and the maintenance test was given immediately after training.

During the generalization phase, training affected the transferred mnemonic activities of all subjects. However, from a consideration of analyses including adults, it appears that training differentially affected the students depending on grade. In comparison to an adult norm, the similarity of pause patterns and recall were greater for twelfth graders than for tenth, and least similar for sixth graders. This conclusion is quite tentative since in the overall analysis involving phases, only one higher order interaction involving grade was found.

Inspection of the trained and untrained sixth graders' pause-patterns suggested that training had a "general" effect on the instructed children's treatment of TBR information. Therefore, training did have some effect on--although not the expected improvement in--the executive's monitoring function. Apparently, training alerted sixth graders to the fact that they should be more active in their remembering processes; however, these children were incapable of translating this information into a pattern of behaviors similar to those activities trained.

The generalized training effects for the older children were much more effective. The trained tenth graders used a modified form of the instructed "cumulative rehearsal, fast-finish" strategy. In comparison to untrained children this pattern of results suggested that training directly affected the tenth graders' monitoring of an effective routine. These trained children, though, did not use the instructed strategy in a manner most similar to that found for an adult norm. Nevertheless, these findings supported the conclusion that trained tenth graders recognized the potential usefulness of the instructed routine, thus monitoring their strategic mnemonic activities.

Training also affected the way in which tenth graders treated TBR and TBF items. Like the younger children, trained tenth graders differentiated item types. The between group comparisons for tenth graders showed that the trained children's differentiate item type treatment was more effective in meeting the generalization task demand than the strategy used by the untrained group. This evidence supports the general notion that training affected the executive control of mnemonic behavior.

The generalization phase performance for trained twelfth graders showed that they transferred the instructed routine and used it in a fashion most similar to that reported for spontaneous producers--adults. Thus, the twelfth

graders not only recognized the potential of the trained routine but also used it effectively in a changed task format.

The results of the present study suggest that training affects executive functioning in various ways. These effects appear to vary at different ages when trained younger children are compared to spontaneous producers; that is, the older the trained child, the greater the similarity between his generalized routine and that of an adult. Also, instruction affected the trained children's monitoring of a generalized mnemonic routine since TBR items were processed in a qualitatively different way than TBF ones--a conclusion similar to that drawn from the adult data. This item type effect suggests that these children deliberately (and not in a rote fashion) used the generalized strategy. Since the selective treatment of TBR information characterized their behavior, this evidence strongly supports the notion that the executive function was affected directly by training.

In both the maintenance and generalization phases the training effects seemed to interact with the children's level of cognitive maturity. Even though sixth grade children benefited from training, their recall during the maintenance and especially generalization phases, did not equal that found for older children and adults. Thus, tenth and twelfth graders were more capable of monitoring their own effective memory processes in maintaining and generalizing a trained mnemonic routine than were sixth graders.

These conclusions were supported by the observational data and the post-test interviews. Sixth graders verbalized an awareness of active mnemonic behaviors, but this apparent awareness had little effect on their actual recall. Older children and adults also expressed a knowledge of active mnemonics and this awareness was related to their observed behavior. This pattern of results is similar to that reported by others, e.g., Flavell et al. (1970), Salatas and Flavell (1976), in that more mature children are able to recognize, use, and maintain effective, strategic behaviors (Brown, Campione, Bray, & Wilcox, 1973; Butterfield & Belmont, 1976; Campione & Brown, 1974, 1977; Reese, 1962; and Rohwer, 1973).

A final note is needed on one of the most engaging problems in the study of cognitive functioning; that is, the problem of making inferences from data hypothesized to reflect some underlying cognitive phenomena. Specifically, in the present study, a single measure of rehearsal, e.g., pause-time or proportion correct, etc., results in a level of inference regarding the "executive function" different from that based on any other unique measure. The fact that each measure used here did not lead to identical inferences concerning the executive exemplifies the experimenter's dilemma in choosing the measure(s) most highly related to the process of interest. Can rehearsal activity be inferred best from pause patterns as Butterfield and Belmont (1976) and Belmont and Butterfield (1977) suggest? Or, can rehearsal be accurately measured by the magnitude of the primacy effect and this be used as the index of developmental differences? The point is that the identification of any mnemonic activity, e.g., rehearsal, depends primarily on the measure chosen. The type of data recorded theoretically reflects and defines the process studied. However, various measures thought by the experimenter to reflect the same processes could represent different levels of similar activities or different processes altogether. Furthermore, the measure used will (to a degree) determine the age at which mnemonic usage is said to occur. For example, Wellman, Ritter, and Flavell (1975) have reported that 3-year-olds use strategic behaviors when instructed to remember a location, whereas in the present study, the observational data would suggest that 17-year-olds do not spontaneously rehearse.

No immediate solution to this problem is proposed. However, one reasonable approach would be to base any inference on what Brown (1977) describes as "convergent operations." That is, as multiple measures of theorized cognitive activities agree, one has increased confidence in the inferences based on those measures.

In the present experiment, the different pattern of results suggested by the separate dependent variables highlights the need for many measures of the same (hypothesized) activities. Inferences regarding the executive function would have differed from those made here if any single measure had been considered. Thus, only by integrating the information obtained from the various measures could a more complete understanding of the executive and its monitoring function be obtained.

The discussion presented above points out that any description of cognition or cognitive development will be a function of a complex interaction among the factors within the individual, his skills and abilities, as well as the chosen tasks (Flavell, 1970).

Footnotes

[1] This paper is based on a doctoral disseration submitted to the University of Illinois at Urbana-Champaign. The research was supported by Grants HD 06864 and HD 05951 from the National Institute of Child Health and Human Development. The author is indebted to his advisor, Ann L. Brown, for her encouragement and support during this project. A special thanks is also given to Drs. Joseph C. Campione, Karl M. Newell, Donald R. Omark, and Maurice M. Tatsuoka. Gratitude is expressed to Mr. William McNealy, Superintendent of the Unit 7 School District, Tolono, Illinois, and to the students for their voluntary participation in this project. A portion of these data were presented at the Society for Research in Child Development Biennial Convention in New Orleans, Louisiana, March 17 - 20, 1977.

[2] Sex interacted with Item Type and Serial Position, F (5,140) = 2.32, $p < .05$. Males paused longer after TBR than TBF items than did females. This behavior was differential over serial positions.

[3] All of the adults indicated verbally that they used a "cumulative rehearsal, fast-finish" strategy.

References

Belmont, J. M., & Butterfield, E. C. The relations of short-term memory to development and intelligence. In L. C. Lipsitt & H. W. Reese (Eds.), Advances in child development and behavior (Vol. 4). New York: Academic Press, 1969.

Belmont, J. M., & Butterfield, E. C. Learning strategies as determinants of memory deficiencies. Cognitive Psychology, 1971, 2, 411-420.

Belmont, J. M., & Butterfield, E. C. The instructional approach to developmental cognitive research. In R. V. Kail, Jr. & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Bray, N. W. Controlled forgetting in the retarded. Cognitive Psychology, 1973, 5, 288-309.

Brown, A. L. The role of strategic behavior in retardate memory. In N. R. Ellis (Ed.), International review of research in mental retardation (Vol. 7). New York: Academic Press, 1974.

Brown, A. L. The development of memory: Knowing, knowing about knowing, and knowing how to know. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 10). New York: Academic Press, 1975.

Brown, A. L. Knowing when, where and how to remember: A problem of matacognition. In R. Glaser (Ed.), Advances in instructional psychology. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Brown, A. L., & Barclay, C. R. The effects of training specific mnemonics on the metamnemonic efficiency of retarded children. Child Development, 1976, 47, 71-80.

Brown, A. L., Campione, J. C., Bray, N. W., & Wilcox, B. L. Keeping track of changing variables: Effects of rehearsal training and rehearsal prevention in normal and retarded adolescents. Journal of Experimental Psychology, 1973, 101, 123-131.

Butterfield, E. C., & Belmont, J. M. Relations of storage and retrieval strategies as short-term memory processes. Journal of Experimental Psychology, 1971, 89, 319-328.

Butterfield, E. C. & Belmont, J. M. The role of verbal processes in short-term memory. In R. L. Schiefelbusch (Ed.), Language research with the mentally retarded. Baltimore: University Park Press, 1972.

Butterfield, E. C., & Belmont, J. M. Assessing and improving the cognitive functions of mentally retarded people. In I. Bailer & M. Sternlicht (Eds.), Psychological issues in mental retardation. Chicago: Aldine, 1976.

Butterfield, E. C., Wambold, C., & Belmont, J. M. On the theory and practice of improving short-term memory. American Journal of Mental Deficiency, 1973, 77, 654-669.

Campione, J. C., & Brown, A. L. The effects of contextual changes and degree of component mastery on transfer of training. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 9). New York: Academic Press, 1974.

Campione, J. C., & Brown, A. L. Memory and metamemory development in educable retarded children. In R. V. Kail, Jr. & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Corsini, D. A. Developmental changes in the effect of nonverbal cues on retention. Developmental Psychology, 1969, 11, 425-435.

Corsini, D. A., Pick, A. D., & Flavell, J. H. Production of nonverbal mediators in young children. Child Development, 1968, 39, 53-58.

Ellis, N. R. Memory Processes in retardates and normals. In N. R. Ellis (Ed.), International review of research in mental retardation (Vol. 4). New York: Academic Press, 1970.

Flavell, J. H. Developmental studies of mediated memory. In H. W. Reese & L. P. Lipsitt (Eds.), Advances in child development and behavior (Vol. 5). New York: Academic Press, 1970.

Flavell, J. H. First discussant's comments: What is memory development the development of? Human Development, 1971, 14, 272-278.

Flavell, J. H., Beach, D. H., & Chinsky, J. M. Spontaneous verbal rehearsal in a memory task as a function of age. Child Development, 1966, 37, 283-299.

Flavell, J. H., Friedrichs, A. G., & Hoyt, J. D. Developmental changes in memorization processes. Cognitive Psychology, 1970, 1, 324-340.

Flavell, J. H., & Wellman, H. M. Metamemory. In R. V. Kail, Jr. & J. W. Hagen (Eds.), Perspectives on the development of memory and cognition. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1977, in press.

Hagen, J. W. The effect of distraction on selective attention. Child Development, 1967, 38, 685-694.

Hagen, J. W. Some thoughts on how children learn to remember. Human Development, 1971, 14, 262-271.

Hagen, J. W. Strategies for remembering. In S. Farnham-Diggory (Ed.), Information processing in children. New York: Academic Press, 1972.

Hagen, J. W., & Hale, G. A. The development of attention in children. In A. D. Pick (Ed.), Minnesota symposia on child psychology (Vol. 7). Minneapolis: University of Minnesota Press, 1973.

Hagen, J. W., Hargrave, S., & Ross, W. Prompting and rehearsal in short-term memory. Child Development, 1973, 44, 201-204.

Hagen, J. W., & Kingsley, P. R. Labelling effects in short-term memory. Child Development, 1968, 39, 113-121.

Hagen, J. W., Meacham, J. A., & Mesibov, G. Verbal labelling, rehearsal, and short-term memory. Cognitive Psychology, 1970, 1, 47-58.

Keeney, T. J., Cannizzo, S. R., & Flavell, J. H. Spontaneous and induced verbal rehearsal in a recall task. Child Development, 1967, 38, 953-966.

Kellas, G., & Butterfield, E. C. Effect of response requirement and type of material on acquisition and retention performance in short-term memory. Journal of Experimental Psychology, 1971, 88, 50-56.

Kendler, T. S., Kendler, H. H., & Wells, D. Reversal and non-reversal shifts in nursery school children. Journal of Comparative and Physiological Psychology, 1960, 52, 387-389.

Kingsley, P. R., & Hagen, J. W. Induced versus spontaneous rehearsal in short-term memory in nursery school children. Developmental Psychology, 1969, 1, 40-46.

Kobasigawa, A. Utilization of retrieval cues by children in recall. Child Development, 1974, 45, 127-134.

Markman, E. M. Factors affecting the young child's ability to monitor his memory. Unpublished Ph.D. dissertation, University of Pennsylvania, 1973.

Masur, E. F., McIntyre, C. W., & Flavell, J. H. Developmental changes in apportionment of study time among items in a multitrial free recall task. Journal of Experimental Child Psychology, 1973, 15, 237-246.

Moely, B. E., Olson, F. A., Halwes, T. C., & Flavell, J. H. Production deficiency in young children's clustered recall. Developmental Psychology, 1969, 1, 26-34.

Pinkus, A. L., & Laughery, K. R. Recording and grouping processes in short-term memory: Effects of subject-paced presentation. Journal of Experimental Psychology, 1970, 85, 335-341.

Reese, H. W. Verbal mediation as a function of age level. Psychological Bulletin, 1962, 59, 502-509.

Ritter, K., Kaprove, B. H., Fitch, J. P., & Flavell, J. H. The development of retrieval strategies in young children. Cognitive Psychology, 1973, 5, 310-321.

Rohwer, W. D., Jr. Elaboration and learning in children and adolescence. In H. W. Reese (Ed.), Advances in child development and behavior (Vol. 8). New York: Academic Press, 1973.

Ryan, S. M., Hegion, A. G., & Flavell, J. H. Nonverbal mnemonic mediation in preschool children. Child Development, 1970, 41, 539-550.

Salatas, H., & Flavell, J. H. Behavioral and metamnemonic indicators of strategic behaviors under remembered instructions in first grade. Child Development, 1976, 47, 80-89.

Scheffé, H. A. The analysis of variance. New York: Wiley, 1959.

Scott, K. G. A multiple-choice audio-visual discrimination apparatus with quick interchange display and response panels. Journal of Experimental Child Psychology, 1970, 9, 43-50.

Wellman, H. M., Ritter, K., & Flavell, J. H. Deliberate memory behavior in the delayed reactions of very young children. Developmental Psychology, 1975, 11, 780-787.

Table 1

Descriptive Statistics

Grade	Statistic	Group: Training	No Training	Spontaneous	Total
6	N	9	9	-	18
	CA:				
	Mean	137.2	137.8		
	Range	132-147	132-149		
10	N	9	9	2	20
	CA:				
	Mean	185.1	190.1	190.5	
	Range	183-189	183-199	186-195	
12	N	9	9	3	21
	CA:				
	Mean	212.3	212.8	214.3	
	Range	204-221	197-220	210-216	
Adult	N	-	-	9	9
	CA:				
	Mean			327.6	
	Range			228-549	

Note. Ages are given in months.

Table 2

The Proportion of Subjects Giving Active and Passive Responses to the Posttest Question

		Type of Response					
		Active			Passive		
Grade	N	Training	No Training	Spontaneous	Training	No Training	Spontaneous
6	15	1.0	.89	--	.00	.11	--
10	20	.89	.78	1.0	.11	.22	.00
12	21	1.0	1.0	1.0	.00	.00	.00

Note. Data on two trained sixth graders are missing due to tape recorder failure.

Figures

Figure 1. Average median pause-times (secs.) and proportion correct for trained and untrained subjects in the assessment, maintenance, and generalization phases.

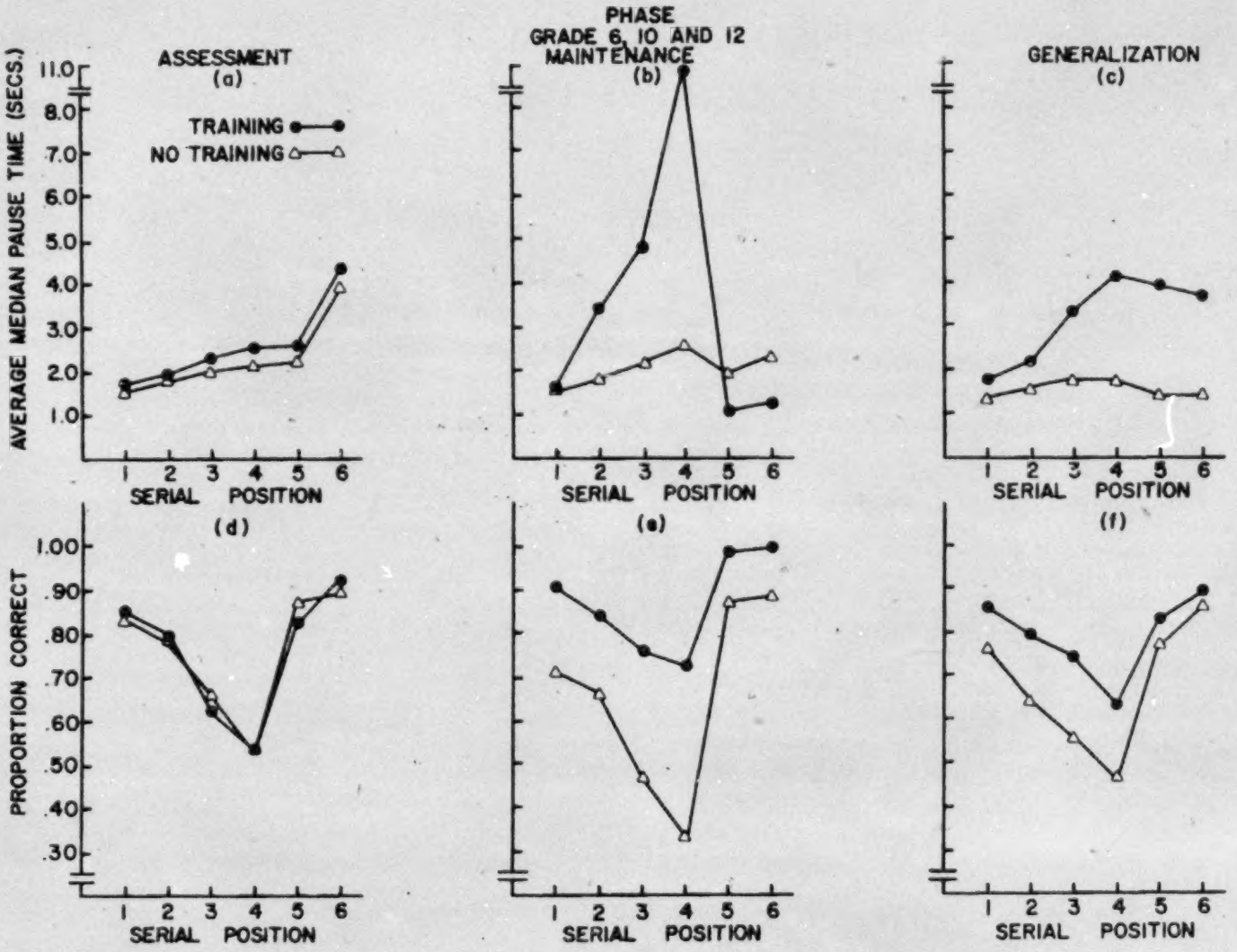
Figure 2. Proportion of items correctly recalled in circular order for Grades 6, 10, and 12 at each serial position.

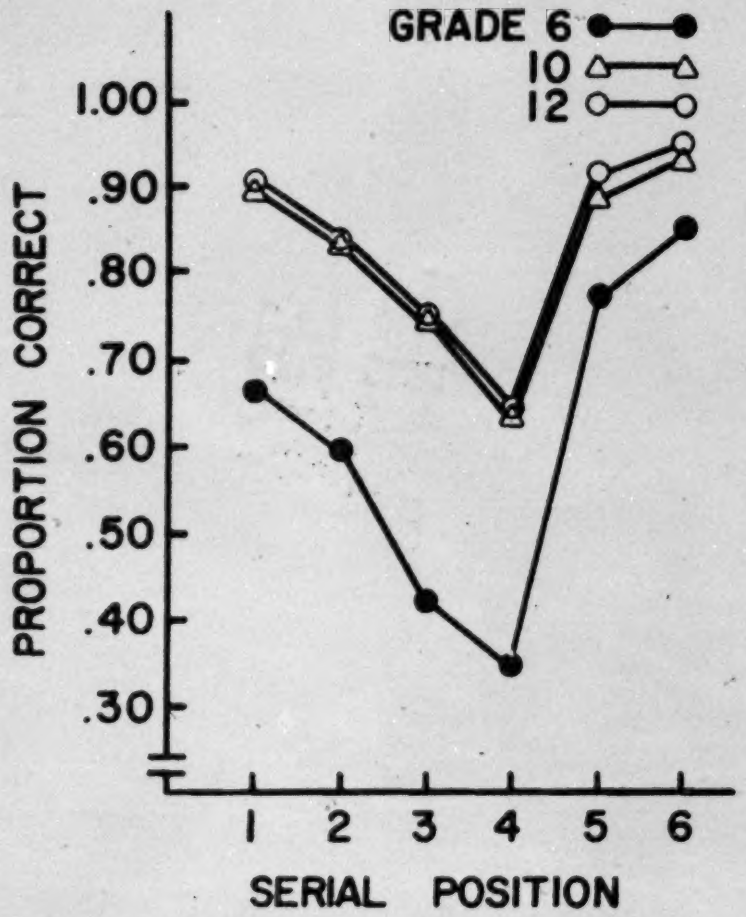
Figure 3. Average median pause-times (secs.) for trained subjects in Grades 6, 10, and 12 plus adults in the assessment and generalization phases.

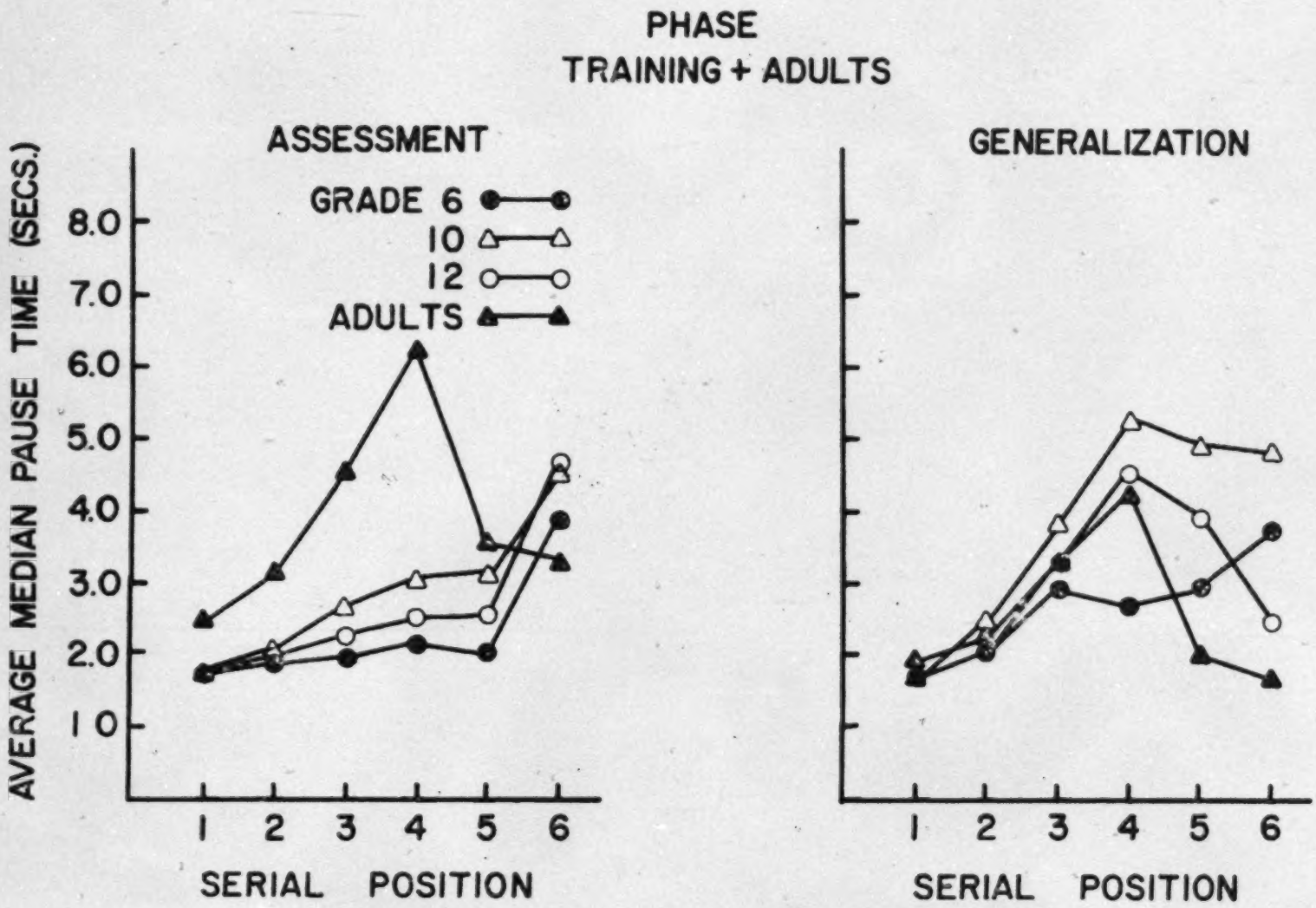
Figure 4. Average median pause-times (secs.) for trained and untrained subjects (summed over Grades 6, 10, and 12) on to-be-remembered (TBR) and to-be-forgotten (TBF) items at each serial position.

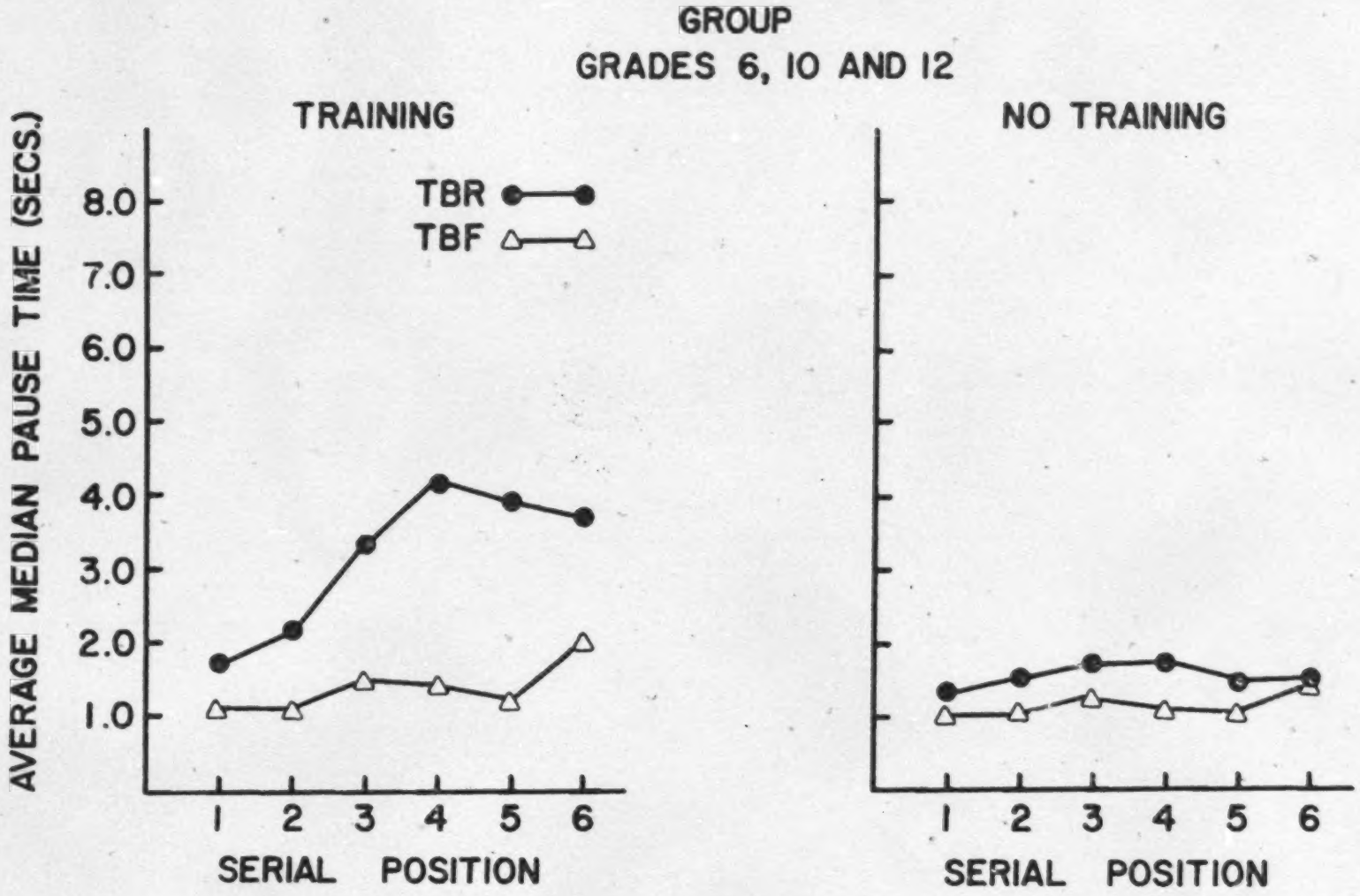
Figure 5. Average number of responses per trained subject on labeling, rehearsal, cumulative rehearsal, gesturing, and cumulative gesturing.

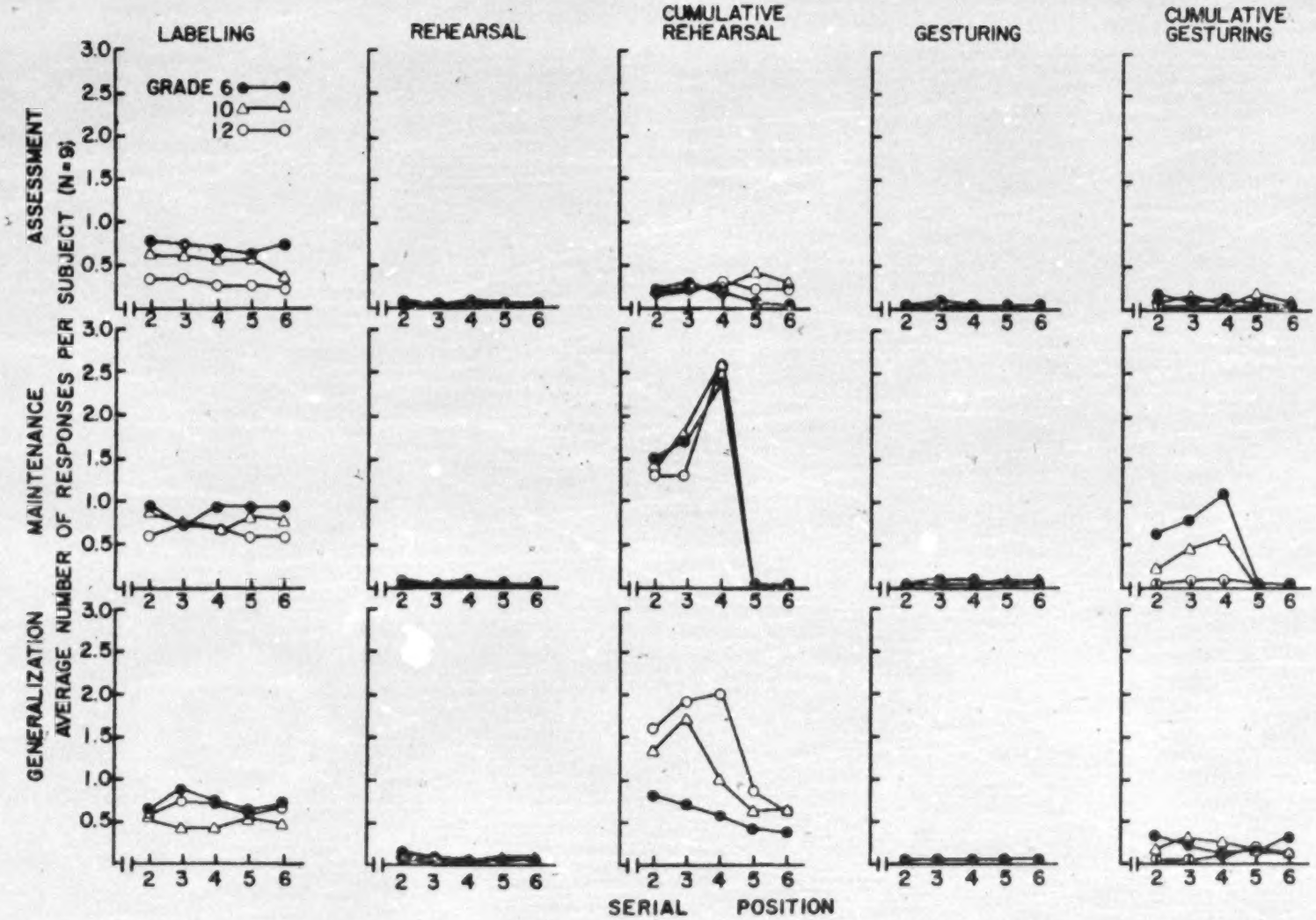
Figure 6. Average number of responses per untrained subject on labeling, rehearsal, cumulative rehearsal, gesturing, and cumulative gesturing.

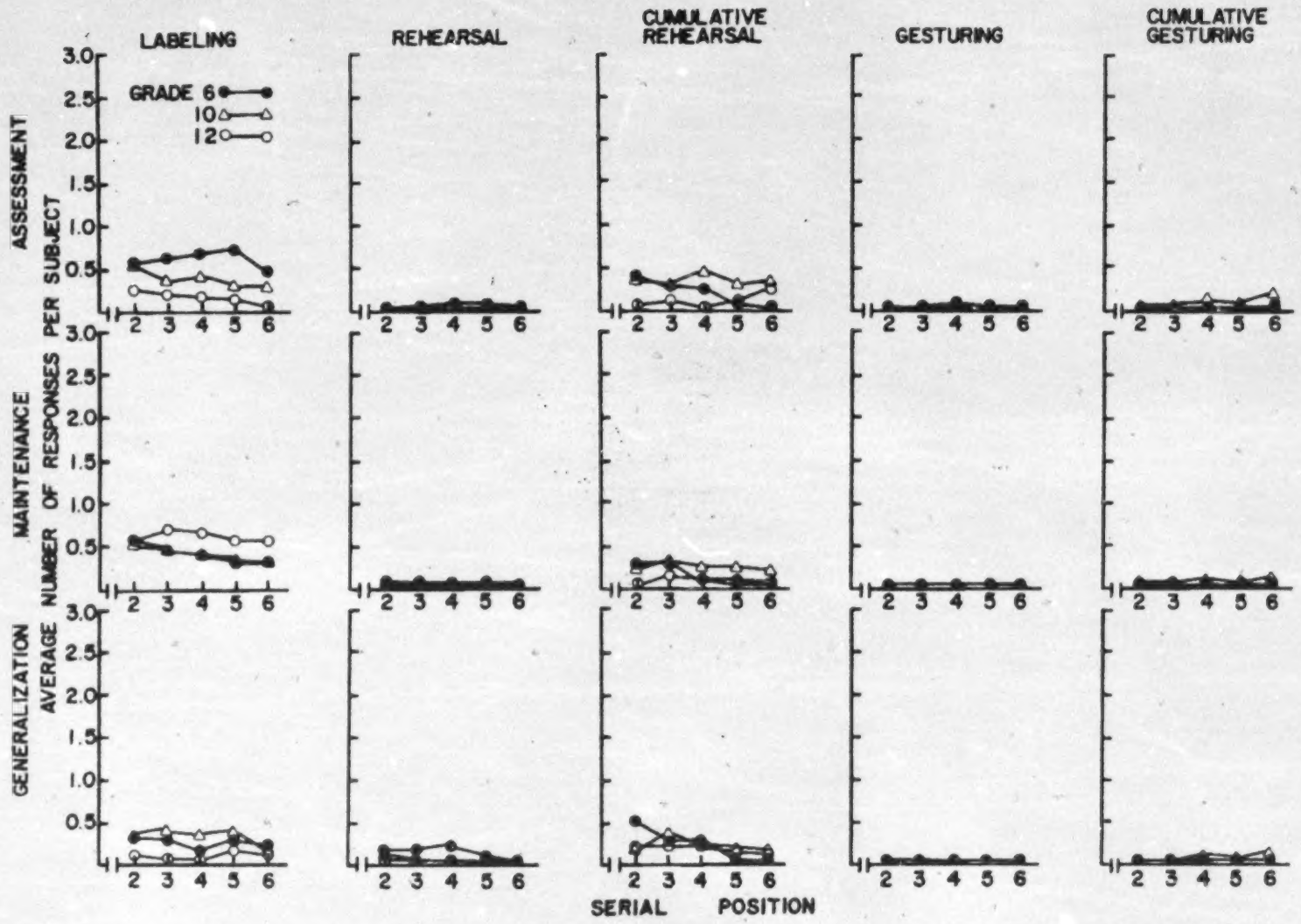

PHASE
GRADE 6, 10 AND 12
MAINTENANCE
ASSESSMENT
(a)
(b)
GENERALIZATION
(c)
TRAINING
NO TRAINING
AVERAGE MEDIAN PAUSE TIME (SECS.)
11.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
1 2 3 4 5 6
SERIAL POSITION
(d)
(e)
(f)
PROPORTION CORRECT
1.00
.90
.80
.70
.60
.50
.40
.30


GRADE 6
10
12
1.00
.90
.80
.70
.60
.50
.40
.30
PROPORTION CORRECT
1
2
3
4
5
6
SERIAL POSITION


PHASE
TRAINING + ADULTS
ASSESSMENT
GENERALIZATION
GRADE 6
10
12
ADULTS
AVERAGE MEDIAN PAUSE TIME (SECS.)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
1 2 3 4 5 6
SERIAL POSITION
1 2 3 4 5 6
SERIAL POSITION


GROUP
GRADES 6, 10 AND 12
TRAINING
NO TRAINING
AVERAGE MEDIAN PAUSE TIME (SECS.)
TBR
TBF
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
1 2 3 4 5 6
SERIAL POSITION
1 2 3 4 5 6
SERIAL POSITION


LABELING
REHEARSAL
CUMULATIVE REHEARSAL
GESTURING
CUMULATIVE GESTURING
GRADE 6
10
12
ASSESSMENT
MAINTENANCE
GENERALIZATION
AVERAGE NUMBER OF RESPONSES PER SUBJECT (N=9)
SERIAL POSITION


LABELING
REHEARSAL
CUMULATIVE REHEARSAL
GESTURING
CUMULATIVE GESTURING
GRADE 6
10
12
ASSESSMENT
MAINTENANCE
GENERALIZATION
AVERAGE NUMBER OF RESPONSES PER SUBJECT
SERIAL POSITION
3.0
2.5
2.0
1.5
1.0
0.5
2 3 4 5 6